PATENT SPECIFICATION (11) 1 509 102

1 509 102

(21) Application No. 17463/76 (22) Filed 29 April 1976
(31) Convention Application No. 573 739
(32) Filed 1 May 1975 in
(33) United States of America (US)
(44) Complete Specification published 26 April 1978
(51) INT CL² H05B 3/42
(52) Index at acceptance
H5H 105 131 141 142 153 157 178 194 224 231 232 254 AF BE1

(54) ELECTRICAL HEATING ELEMENT

(71) We,, NATIONAL ELEMENT INC, a Corporation organised and existing under the laws of the State of Michigan, United States of America, of 422, Oliver Street, Troy, Michigan, 48084, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to heating elements for high-temperature furnaces and, more particularly, to an improved heating element for use in a radiant tube heater in a high-temperature furnace.

The use of radiant tube heaters positioned in high-temperature heat-treating furnaces is, of course, well known. Typically, in the prior art, the interior of a tubular member was gas-fired to heat the tubular member. The tubular member then radiated the heat outwardly into the furnace.

There were various difficulties and problems with gas-fired radiant tube heaters, the most significant of which were the relatively high cost and the low efficiency of gas heating.

The use of electrical heating elements interiorly of a radiant tube is also well known. However, various problems have been encountered with the prior art electrical-heating elements.

Typically, these electrical heating elements include a support structure having a hollow core and an electrical heating assembly. As current is passed through the electrical-heating assembly, the heating assembly radiates heat to the radiant tube, which in turn radiates heat into the furnace.

One problem of the prior art electrical heating elements is lack of stability, i.e., sagging and growth. Sagging is the deviation from the original longitudinal axis and growth is axial elongation, both of which occur during high temperature use of the heating elements due to thermal expansion. One object of this invention is, therefore, to overcome this problem.

Another object of the present invention is to provide a heating element which has its entire electrical path outwardly of a central core so that the entire electrical path generates useable heat for heating the radiant tube or furnace.

Yet another object of the invention is to provide a heating element that enables the use of electrical conductors of a sufficiently thick cross section to reduce oxidation and corrosion. A further object is to provide a form of construction that permits the replacement of those conductors which are pitted, oxidized or corroded without necessitating replacement of the entire electrical assembly.

According to the invention an electrical heating element has a longitudinal axis and a plurality of thin, flat, non-conductive plates which are spaced axially apart along said longitudinal axis, each plate having a plurality of spaced apertures therethrough which are parallel to and are spaced laterally outwardly from said longitudinal axis, the apertures in each plate being arranged in a plurality of circular rows which are spaced laterally apart, the apertures of each row of each plate being respectively longitudinally aligned with the apertures in the corresponding row of the other plates, a plurality of longitudinally aligned non-conductive spacers located on said longitudinal axis and laterally inwardly of said apertures, each of said spacers abutting and engaging the opposing faces of a pair of adjacent plates for maintaining said plates parallel and spaced apart, and a plurality of elongated straight rigid electrical conductors extending parallel to said longitudinal axis and extending axially through the longitudinally aligned apertures in said plates and being supported thereby; and means at each end of the heating element for interconnecting the ends of said conductors to define a single continuous

electrical flow path through said conductors.

Advantageously the electrical conductors consist of a plurality of conductive rods each having elongated legs and a base bight portion, the rod legs being inserted through aligned apertures in each of the discs to extend axially of the disc-spacer assembly and radially outwardly of the spacer, and the bight portion of each rod lying beyond the confines of the end plate, and further including conductive means retaining the rods, discs, and spacers in assembly and interconnecting the rods to provide a single continuous electrical flow path through each of the rods and outwardly of the spacers.

Preferably each pair of rods and the associate base are formed in a U-shape, each leg of each U-shaped rod being inserted axially through the aligned apertures in the series of plates to lie radially outwardly of the spacers, means being provided for interconnecting the free end of each rod leg, with the exception of two rod legs, to the free end of the leg of a different rod to form the rods into a single electrical path, the remaining two rod legs being adapted for connection to an electrical power source.

The foregoing objects and advantages of the present invention, together with other objects and advantages which may be attained by its use, will become more apparent upon reading the following detailed description taken in conjunction with the drawings. In the drawings, wherein like reference numerals identify corresponding elements:

Fig. 1 is an illustration, partly broken away, of the electrical heating element of the present invention inserted in a radiant tube;

Fig. 2 is an enlarged view of the front end of the electrical heating element;

Fig. 3 is an illustration of the electrical heating element of Fig. 1 as seen in the plane of arrows 3-3 with the radiant tube removed;

Fig. 4 is an illustration of the distal end of the electrical heating element as seen in the plane of arrows 4-4 of Fig. 1;

Fig. 5 is an illustration of the proximal of the electrical heating element as seen in the plane of arrows 5-5 of Fig. 1; and

Fig. 6 is an illustration of the front end of the electrical heating element of the present invention as seen in the plane of arrows 6-6 of Fig. 1.

The electrical heating element 10 of the present invention is illustrated in Fig. 1 positioned in a hollow tube 11 having a closed distal end 12 and a flanged proximal end 13 for attachment to a furnace. The tube 11 is preferably of a heat-resistant alloy such as that known under the Registered Trade Mark INCONEL although a steel pipe could be used in a lower temperature furnace. The support structure of the electrical heating element of the present invention includes a plurality of thin, flat ceramic plates or discs 15 including first and second plates 16, 17 respectively at the front or first end of the assembly, and penultimate and last plates 18 and 19 at the distal end of the assembly.

Each of the plates is preferably identical and has a central axial bore 20 which is surrounded by a circular groove 21 on each side of the plate. Each plate has a plurality of apertures therethrough parallel to the axis of the plate. These apertures are arranged in a plurality of rows and as illustrated in Fig. 3, there is a first circular row of apertures 22 and a second circular row of apertures 23 with all the apertures being chamfered as at 24. The rows of apertures are radially spaced apart and, in a preferred embodiment, the apertures 22 are offset angularly with respect to the radii through the apertures 23 to provide a maximum direct exposure of the surface of current-carrying conductors to the radiant tube.

The support structure also includes a plurality of identical non-conductive spacers 25, also made of a ceramic material, preferably hollow and cylindrical so as to be open at both ends. The diameter of the spacers 25 corresponds to the diameter of the circular groove 21 in each plate, and it is important that the diameter of the spacers 25 is sufficiently less than the diameter of the plates 15 so that all the apertures 22, 23 are radially outwardly of the spacers 25. One spacer 25 is interposed between each pair of adjacent plates 15 as illustrated in Fig. 4. Hence, the spacers serve to separate the adjacent plates.

The electrical heating assembly of the present invention will now be explained. The present invention includes a plurality of electrical conductors which, in the preferred embodiment, are rigid rods of a circular cross section with the conductors or rods having a generally hairpin or U-shape. The use of a rod of a circular cross section provides a maximum diameter-to-surface area ratio. This provides longer life as contrasted to the prior art electrical heating elements since opportunity for oxidation, pitting or corrosion to penetrate entirely through the rod depends on the thickness of the rod.

Each conductor or rod 30 includes two elongated parallel legs 31, 32 which are joined together by a base or bight 33.

When the support structure is assembled, the apertures of all of the plates are aligned and each rod leg is inserted through the series of aligned apertures parallel to the axes of the plates. The rods are first inserted through the penultimate plate 18 with the bight 33, which forms a connection between

the legs 31 and 32 of each rod, lying beyond the confines of the penultimate plate 18. Thus, the rods extend through each plate and between the adjacent plates from the penultimate plate 18 through each plate 15 to the second plate 17 and the distance between plates 17 and 18 define the effective heating length of the heating element 10. Each plate except the end plate 19 locates the rods 30 and the base or bight portion 33 of each rod serves to maintain the distal end of the rod assembly when the element is being assembled.

Additional supporting means are provided at the distal end of the heating element 10 to both support the assembly and to prevent electrical contact between the bases 33 of the rods and the end 12 of the radiant tube. In a preferred embodiment, this includes a spacer 25 and the last plate 19. A pin 35, such as an 18-chrome, 8-nickel, stainless steel pin, is inserted interiorly of the spacer 25. The pin has apertures at each end to receive cotter pins 36. The cotter pins and stainless steel pin prevent the penultimate plate 18 and the last plate 19 from separating and the spacer 25 prevents these two plates from moving closer together.

During assembly of the heating element 10, the rods 30 are inserted through the apertures 22, 23 of the penultimate plate 18. Then, the support structure of the stainless steel pin 35, spacer 25 and the last plate 19 is assembled. Finally, the remaining support structure including the plates 15 and 17 and spacers 25 are assembled with the rods extending through the aligned apertures 22, 23 in each plate.

Means are provided for electrically interconnecting the free ends of the legs 31, 32 of the rods and for maintaining the support structure of the plates and spacers in assembly. With respect to Figs. 2, 5 and 6, all the legs 31, 32 of the rods 30 are illustrated as extending through the apertures in the second ceramic plate 17. A series of connector rods 40 are illustrated in Fig. 5. These connector rods 40, which are of the same size and material as the conductive rods 30, are welded to the free end of one leg 31 of a U-shaped conductor and to the free end of a leg of a different U-shaped conductor. The interconnection of the free ends of the legs of the conductive rods is accomplished with four legs of four different U-shaped rods remaining unconnected as illustrated in Fig. 5 by the four leg ends 41, 42.

Then, the first ceramic plate 16 is placed into position with the four leg ends 41, 42 extending therethrough. A straight bar 43 of the same material as the connector rods 40 and conductors 30 is then welded to two of the free leg ends 42. This leaves the two leg ends 41 ready for the connection to terminals but at the same time provides a continuous electrical path from one free leg end 41 along a path through each U-shaped conductor in turn and each connector rod and the straight bar which electrical path emerges at the other free leg end 41. The entire electrical path, along the legs 31, 32 of the rods 30 therefore, is radially outwardly of the spacers 25 (apart from the straight bar 43).

With reference to Figs. 1 and 2, the remainder of the support assembly and electrical connection will now be explained. It is preferable to reduce the distance between the two free leg ends 41 of the rod to a distance more suitable for interconnection to an electrical supply source and, at the same time, provide terminals of a greater thickness for such interconnections. Furthermore, it is desired to provide additional support for this first end of the heating element. To accomplish this, two rods 45 of the same material as the conductors 30 but of a slightly greater diameter are welded as at 46 to the free leg ends 41. The upper ends of the rods 45 are welded as at 47 to the ends of two terminal rods 48 which are preferably 35-15 stainless steel. These terminal rods 48 are of .625 inch diameter. The terminal rods are inserted through a first insulating block 50 which has two holes 51 therethrough to receive the terminal rods 48 and two additional vent holes 52 therethrough. Washers 53 are welded to the terminal rods on both sides of the first insulating block 50. A satisfactory insulating block is a disc of the material known under the Registered Trade Mark MARINITE manufactured by the John Mansville Company.

The terminal rods extend through a second block 55 of the same material and washers 56 are welded to the terminal rods 48 interiorly of the second insulating block 55. The terminal rods are suitably threaded to receive fly nuts 57 which secure the second insulating block 55 against the washers 56.

A heating element manufactured in accordance with the present invention was tested with the following results. Insulating plates 15 were made of 4.875 inch diameter, 0.5 inch thickness having 17 apertures in the outer row and 17 apertures in the inner row. Then, 17 U-shaped conductors were inserted therethrough and the assembly was placed in a pipe having a 6 inch outside diameter. The effective heating length of the assembly was 42 inches. Thermocouples were placed inside of and outside of the pipe. Power was applied at various voltages between 45-60 volts and at various currents from 30-45 amps. (The heating element is rated at 137 volts). The temperature of the tube was maintained at 2200°F. for 24 hours as part of the testing and at times exceeded

2300°F. Similar tests were run on a larger version with a lower current rating and the temperature outside of the pipe exceeded 1700°F.

The important result of these tests were that there was no measurable sag (variations relative to the longitudinal axis) and no measurable growth of the element (variations in axial length) during the testing. Although these tests were not carried out under actual operating conditions, the test results indicate that the necessary operating conditions of heating a furnace to 2000°F. are obtainable with the present invention and will not result in measurable sag or growth of the electrical heating element.

It must be appreciated that many changes and modifications may be made without departing from the spirit and scope of the present invention. While the use of U-shaped rods, which are easily individually replaceable in the event that a single rod corrodes has been described, it is equally feasible to use straight rods and weld at both ends. Similarly, depending upon the atmosphere of the heat treating furnace, it is possible to utilize the present heating element without a radiant tube. Furthermore, all the spacers of the present invention are hollow although this is not necessary as other arrangements can be made for securing the last plate 19 to the penultimate plate 18.

WHAT WE CLAIM IS:—

1. An electrical heating element having a longitudinal axis and a plurality of thin, flat, non-conductive plates which are spaced axially apart along said longitudinal axis, each plate having a plurality of spaced apertures therethrough which are parallel to and are spaced laterally outwardly from said longitudinal axis, the apertures in each plate being arranged in a plurality of circular rows which are spaced laterally apart, the apertures of each row of each plate being respectively longitudinally aligned with the apertures in the corresponding row of the other plates, a plurality of longitudinally aligned non-conductive spacers located on said longitudinal axis and laterally inwardly of said apertures, each of said spacers abutting and engaging the opposing faces of a pair of adjacent plates for maintaining said plates parallel and spaced apart, and a plurality of elongated straight rigid electrical conductors extending parallel to said longitudinal axis and extending axially through the longitudinal aligned apertures in said plates and being supported thereby, and means at each end of the heating element for interconnecting the ends of said conductors to define a single continuous electrical flow path through said conductors.

2. The electrical heating element defined in Claim 1, wherein each of said conductors is provided with two elongated legs joined by a base, each leg of each conductor extending through one aperture in each row of each plate, and the base of each conductor being positioned beyond an end plate to form at one end of the heating element said interconnecting means.

3. The electrical heating element defined in Claim 2, wherein the interconnecting means at the other end of the heating element includes a plurality of connector rods, each connector rod interconnecting the free end of each conductor leg with the free end of a different conductor leg and with two conductor legs of different conductors remaining free of connector rod interconnection and being adapted for connection to an electrical power source.

4. An electrical heating element according to Claim 1, in which said electrical conductors consist of a plurality of pairs of elongated electrically conductive rigid rods, each rod being inserted axially through the aligned apertures in the plates to lie radially outwardly of the spacers; each pair of rods interconnected by a base, the bases extending beyond the end most plate-spacer unit, said end most plate including a central axial bore radially interiorly of its spacer;

an additional non-conductive thin flat apertured plate having a central axial bore and being spaced apart from said end most plate for further supporting the heating element and for isolating the bases from contacting a radiant tube when the element is mounted in the tube for heating the tube, the additional plate being positioned away from said end most plate and secured thereto by an axial pin extending through its spacer and the central axial bore of said end most plate and of said additional plate, said axial pin secured inwardly of the end most plate and outwardly of the additional plate; and means for electrically interconnecting the free end of said rod, with the exception of two rods of different pairs of rods, to the free end of a rod of a different pair of rods at a first end of the heating element, to form the rods into the single electrical path, the remaining two rods being adapted for connection to an electrical power source.

The electrical heating element defined in Claim 4, wherein each pair of rods together with the base connecting them is formed as an integral U-shaped rod.

6. The electrical heating element defined in any one of the preceding claims, wherein each spacer is hollow and the spacers and plates are each formed as separate units.

7. The electrical heating element defined

in any one of the preceding claims, wherein each plate has a pair of circular rows of apertures including an inner circular row and an outer circular row, with the apertures in the inner row being located closer together than the apertures in the outer row, and with the apertures in each row being equally spaced apart.

8. The electrical heating element defined in any one of the preceding claims, wherein the opposing faces of adjacent plates are provided with circular grooves, with the end portions of each spacer being received in the grooves of adjacent plates, each spacer being cylindrical.

9. An electrical heating element substantially as described hereinbefore with reference to the accompanying drawings.

Agents for the Applicants
NPM HUGHES CLARK ANDREWS & BYRNE
5 Stone Buildings,
Lincoln's Inn
London WC2A 3XT

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1978.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1509102 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 1

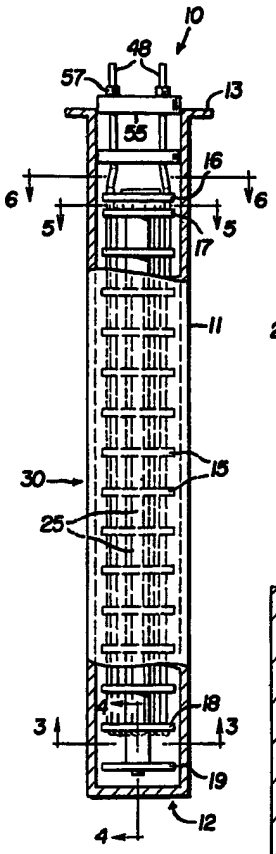
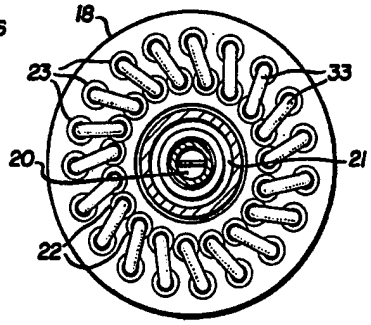


FIG. 3



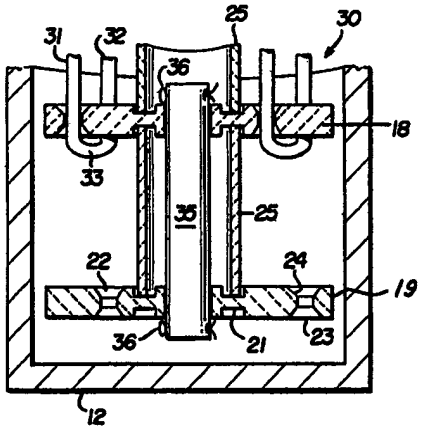


FIG. 4

1509102 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

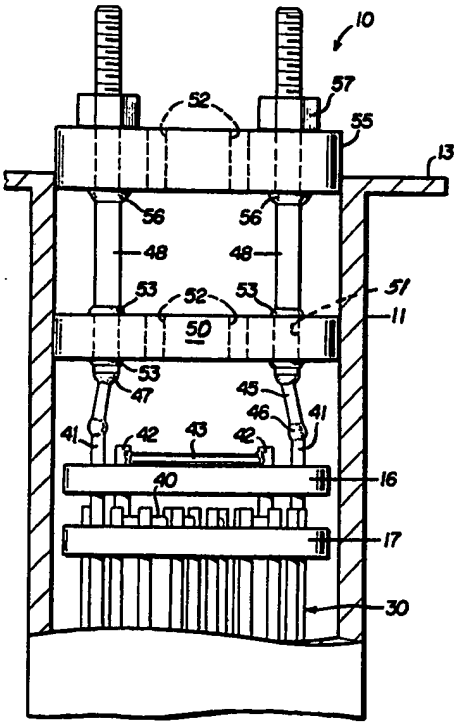
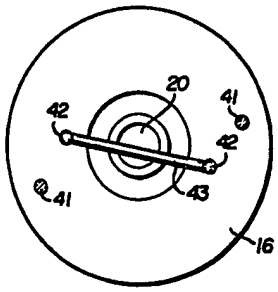


FIG. 2

FIG. 6



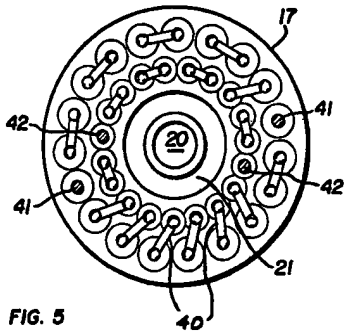


FIG. 5